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13. ABSTRACT (Maximum 200 words)  The List of equipment purchased is as follows: (1) Princeton Gamma-Tech IMIX-IV system (2) Camera/monitor package (3) Remote workstation (4) PC with optical disk drive and printer (5) Ethernet interface for PC (6) Stage motorization package (7) Peak Wavelength spectrometer. Approximately 20 graduate students and several faculty from four different departments on campus have made use of the new equipment, with about 8 people using the equipment on a weekly basis. The equipment is operated on two 8 hour shifts Monday through Friday occasional used on weekends.				
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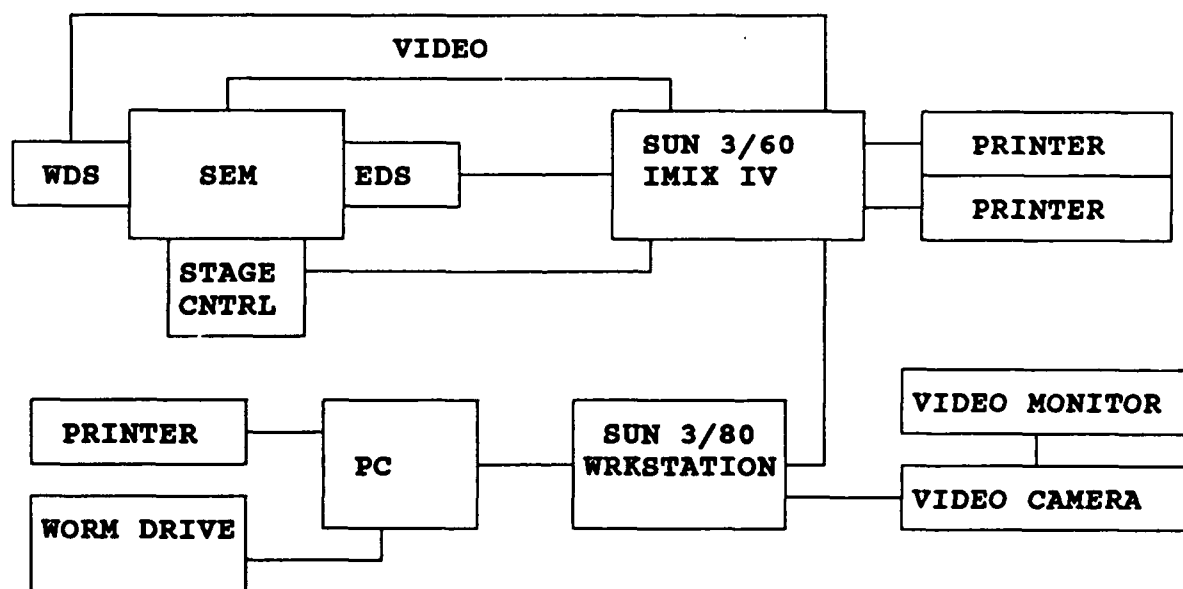
### Acquisition of an Analytical X-ray and Image Analysis System

The list of equipment purchased is as follows:

- 1) Princeton Gamma-Tech IMIX-IV system
- 2) Camera/monitor package
- 3) Remote workstation
- 4) PC with optical disk drive and printer
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- 6) Stage motorization package
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Items 2,3,5 and 6 have not yet been delivered, the supplier has quoted 60 days for delivery.

A schematic of the hardware configuration is shown in Figure 1.



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## **Technical Reports**

### **1. "Alloy Phase Equilibria in NiAl based Ternary Systems.**

**PI: Philip Nash**

**Students: G. Cha and M. Sikaress**

A study of high temperature phase equilibria in several Ni-based ternary alloy systems is being made with the purpose of establishing the phase relationships involving the  $\beta$ (NiAl) phase. Some binary systems are being investigated also where there is doubt about the phase diagram, before proceeding to the ternary system. The alloy systems currently being investigated are Ni-Al-Sb, Ni-Bi and Ni-Sn. EDS analysis is being used to establish the phase equilibria in the Ni-rich corner of the Ni-Al-Sb system at 1000°C. Equilibria involving NiAl, Ni<sub>3</sub>Al, (Ni) and Ni<sub>5</sub>Sb<sub>2</sub> have been established and the possible existence of a ternary compound is being investigated. In the Ni-Sn and Ni-Bi systems we are investigating the composition range of several intermetallic compounds prior to investigation of the respective ternary equilibria. Figure 2. shows an EDS spectra gathered from a Ni-Sn intermetallic compound.

### **2. Mechanical Alloying of NiAl based Alloys**

**PI: Philip Nash**

**Students: S.J.Hwang and H. Ardy**

Alloys based on the intermetallic  $\beta$ (NiAl) are being produced by mechanical alloying and consolidated by various methods. The equipment purchased is being used to characterize the powders with regard to chemical composition, using the EDS, and particle morphology, microstructure and size distribution, using the image analyser. The equipment is also used to characterize consolidated material for chemical analysis and porosity.

### **3. Mechanical Alloying of Ti-based Alloys**

**PI: Philip Nash**

**Students: H. Kim and H. Choo**

Alloys based on the intermetallic compounds TiAl and TiCo are being mechanically alloyed and consolidated. Characterization of the powders and bulk material involves EDS analysis for chemical composition and image analysis for powder morphology and particle size distribution.

### **4. Grain Boundary Effects in Intermetallics**

**PI: Marek Dollar and Philip Nash**

**Student: S.J.Hwang**

A study is being made of the role of grain boundaries in NiAl based intermetallics. This involves microstructural studies mostly utilizing transmission electron microscopy, but also using the SEM, EDS and image analyser for characterization of material produced and fracture surfaces. This program is just beginning and we are currently producing and

characterizing the material to be used in this study.

## **5. Hydrogen Effects in Ni-Base Superalloys**

**PI: M. Dollar**

Haynes alloy 242, Ni-25%Mo-8%Cr, depends upon a long range ordering response to heat treatment. The emphasis of this research was on the effects of hydrogen on yielding, flow and fracture. Fractography of the fractured surfaces on hydrogen-charged and uncharged samples was done using the SEM. The fracture surfaces of the charged samples revealed an intergranular fracture mechanism and many intergranular cracks were observed. The uncharged samples revealed ductile fracture in the form of microvoid coalescence.

Nickel-base superalloy single crystal superalloy CMSX-2 was investigated. The emphasis of this research was on the effects of hydrogen on low-cycle fatigue behaviour. SEM was used to to determine the effects of hydrogen on fatigue failure. The most important result of these studies was that hydrogen promoted highly crystallographic, stage I {111} slip plane fracture, which leads to embrittlement.

## **6. Stability of $L1_2$ compounds based on $Al_3Zr$**

**PI: Philip Nash and Ricardo Schwarz(LANL)**

**Student: Paul Desch**

One technique of ductilizing brittle intermetallics is to modify the crystal structure to one with a larger number of active slip systems. We are studying the effect of alloying on the crystal structure of  $Al_3Zr$  produced by mechanical alloying. The study is based on the fundamental calculations of lattice stability which suggest that by appropriate alloying of  $Al_3Zr$  the  $L1_2$  structure can be stabilized. The phase relations between stable  $L1_2$  phases and Al are also being investigated. The instrument is being used to characterize MA powders and compacts for particle size and morphology, porosity and chemical composition.

## **7. Fractographic Studies of Al 7191-SiC Metal Matrix Composites**

**PI: M. Bernstein, S. Mostovoy and M. Dollar**

**Student: M. Yousef**

Fractographic examinations of tensile and crack arrest specimens were conducted using SEM. Several fracture modes were revealed, these included particle cracking by cleavage, matrix failure by microvoid coalescence and intergranular fracture. Fracture by delamination along the oxide layers present along grain boundaries was also found. The dominant oxide layers in these P/M materials were found to be MgO which forms by reaction between oxygen present on the powder surfaces before blending and Mg which is a constituent element of Al 7191. A quantitative study on the fracture initiation sites was conducted. The failed tensile bars exhibited a river pattern which was traced back to the discrete failure initiation site. The surface chemistry of these sites were obtained using energy dispersive x-

ray analysis.

The pre-polished side surfaces of the crack arrest specimens were examined to study the deformation field ahead of the crack tip. A large amount of microcracks were found which were associated with SiC particles. The size of zone enveloping these microcracks was measured and compared with finite element calculations. This enabled interpretation of the constitutive response of these composites. Moreover, the EDS method was used to obtain the average area of SiC particles on the fracture surface. This was conducted at low magnifications and was obtained as a function of the matrix temper (T4, U/A, P/A and O/A) and the stress state (plane stress and plane strain). This study was considered to be qualitative due to the topography of the fracture surfaces. While the matrix temper does not have a significant effect on the average area of SiC on the fracture surfaces, plane stress conditions exhibited average area 30% higher than that for plane strain stress state.

## Chemical Engineering

### Effects of Periodic Current Modulation in Electrodeposition of Zinc-Nickel Alloys

PI: J.R.Selman

Student: Yu-Po Lin

The objective of this program is to study the properties ( in particular, corrosion protection) of Zn-Ni alloy coating electrodeposited by pulse techniques. The imaging capabilities of the IMIX system are being used to study the morphology and grain sizes of the deposits which are related to the nucleation rate during electrodeposition. The composition of the deposited layer is also being explored, using the EDS system.

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